Attachment H

Proposal # 2001-F-207 (Office Use Only)

PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Contaminant source control in the watershed: an evaluation of the in situ removal of mercury from groudwater using PRBs (Permeable Reactive Barriers)

Applicant Name: David W. Blowes, University of Waterloo

Contact Name: David Blowes, Professor

Mailing Address: Department of Earth Sciences, 200 University Avenue W, Waterloo, Ontario, Canada, N2L-3G1

Telephone: (519) 888-4878

Fax: (519) 746-3882

Email: blowes@sciborg.uwaterloo.ca

Amount of funding requested: $ $208,235

Some entities charge different costs dependent on the source of the funds. If it is different for state or federal funds list below.

State cost _____ Federal cost _____

Cost share partners? **X Yes** **No**

Identify partners and amount contributed by each Homestake Mining Company - $16,500

Indicate the Topic for which you are applying (check only one box).

- ☐ Natural Flow Regimes
- ☐ Nonnative Invasive Species
- ☐ Channel Dynamics/Sediment Transport
- ☐ Flood Management
- ☐ Shallow Water Tidal/ Marsh Habitat
- ☒ Contaminants
- ☐ Beyond the Riparian Corridor
- ☐ Local Watershed Stewardship
- ☐ Environmental Education
- ☐ Special Status Species Surveys and Studies
- ☐ Fishery Monitoring, Assessment and Research
- ☐ Fish Screens

What county or counties is the project located in? Napa County

What CALFED ecozone is the project located in? See attached list and indicate number. Be as specific as possible Putah Creek Watershed, northwest of Yolo Basin (10)

Indicate the type of applicant (check only one box):

- ☐ State agency
- ☐ Public/Non-profit joint venture
- ☐ Local government/district
- ☒ University
- ☐ Other: _____
- ☐ Federal agency
- ☐ Non-profit
- ☐ Tribes
- ☐ Private party

Indicate the primary species which the proposal addresses (check all that apply):

- ☐ San Joaquin and East-side Delta tributaries fall-run chinook salmon
- ☐ Winter-run chinook salmon
- ☐ Spring-run chinook salmon
- ☐ Late-fall run chinook salmon
- ☐ Fall-run chinook salmon
- ☐ Delta smelt
- ☐ Longfin smelt
- ☐ Splittail
- ☐ Steelhead trout
- ☐ Green sturgeon
- ☐ Striped bass
- ☐ White Sturgeon
- ☐ All chinook species
- ☐ Waterfowl and Shorebirds
- ☐ All anadromous salmonids
- ☐ Migratory birds
- ☐ American shad
- ☐ Other listed T/E species: _____

Indicate the type of project (check only one box):

- ☒ Research/Monitoring
- ☐ Watershed Planning
- ☐ Pilot/Demo Project
- ☐ Education
- ☐ Full-scale Implementation

Is this a next-phase of an ongoing project? Yes ____ No__X__
Have you received funding from CALFED before? Yes ____ No__X_

If yes, list project title and CALFED number_____

Have you received funding from CVPIA before? Yes ____ No_X__

If yes, list CVPIA program providing funding, project title and CVPIA number (if applicable):

_____

By signing below, the applicant declares the following:

- The truthfulness of all representations in their proposal;
- The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and
- The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

David W. Blowes
Printed name of applicant

David Blowes
Signature of applicant

University of
Waterloo

Department of
Earth Sciences

Faculty of Science

University of Waterloo
200 University Avenue West
Waterloo, Ontario, Canada
N2L 3G1

519-885-1211
Fax 519-746-7484

CALFED Bay-Delta Program Office
1416 Ninth Street, Suite 1155
Sacramento, California
U.S.A. 95814

May 12, 2000

To whom it may concern:

Attached is a research proposal we are submitting to the CALFED Bay-Delta Program entitled "Contaminant-source control in the watershed: an evaluation of the *in situ* removal of mercury from groundwater using permeable reactive barriers (PRBs)". This proposal includes collaboration from local California organizations including Homestake Mining Corporation, Geochimica, Inc., TRC and an independent consultant (R. Krauss). This is a joint venture partnership with the University of Waterloo coordinating the project.

This proposal describes a series of column experiments that will be conducted solely in a laboratory on Homestake Mining Company property, using site groundwater. The column setup is self-contained and small-scale. The columns will be packed with reactive materials previously identified as being potentially effective useful for removing mercury from groundwater. Full treatment of the dissolved mercury is expected within the reactive materials. Due to the nature of these laboratory research experiments, we believe the proposal is exempt from the local government notification requirement.

As indicated in their attached letter of support, Homestake Mining Company has agreed to provide full use of their facilities on the McLaughlin Reserve, including the Knoxville and McLaughlin Mine sites situated within the Reserve.

Thank you for considering our application for CALFED funding. We look forward to hearing from you.

Sincerely,

David Blowes

David Blowes
Professor, Department of Earth Sciences
Institute for Groundwater Research

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May 11, 2000

CALFED Bay-Delta Program Office
1416 Ninth Street, Suite 1155
Sacramento CA, 95814

RE: **Research Proposal "Contaminant-source control in the watershed: an evaluation of the *in situ* removal of mercury from groundwater using permeable reactive barriers (PRBs)"**

Dear Sir/Madam:

On behalf of Dr. D. Blowes of our Institute for Groundwater Research (IGR), please find enclosed the proposal for the above referenced project.

Our office provides the administration, legal and financial personnel necessary to handle all authorized research proposals and contracting activities. The University of Waterloo is a corporation, and a public institution, in Canada, and is required to conform to the statutes and regulations of the Federal Government of Canada and the Provincial Government of Ontario. We are bound to act according to the requirements of the Canadian Bill of Rights and such other labour laws, including employment opportunity statutes and regulations, as may apply.

Judy Brown, Senior Contracts and Industrial Grants Manager will be pleased to negotiate the applicable terms and conditions in detail to cover this research activity. Judy Brown's business card is enclosed.

If you have any questions of a technical nature please contact Dr. David Blowes at (519) 888-4567 ext. 4878. Questions of an administrative, legal or contractual nature can be addressed to Judy Brown at (519) 888-4567 ext. 2022.

Sincerely,

Brenda Hebner
Manager, Contracts and Industrial Grants

Encl.
Cc: Dr. David Blowes, IGR

COPY

COLLEGES AND UNIVERSITIES RATE AGREEMENT

EIN #: 980061413

DATE: February 25, 1999

INSTITUTION:
University of Waterloo
200 University Avenue, West
Needles Hall, Room 2072
Waterloo, Ontario CN N2L 3G1

FILING REF.: The preceding Agreement was dated January 7, 1997

The rates approved in this agreement are for use on grants, contracts and other agreements with the Federal Government, subject to the conditions in Section III.

SECTION I: FACILITIES AND ADMINISTRATIVE COST RATES*

RATE TYPES: FIXED FINAL PROV.(PROVISIONAL) PRED.(PREDETERMINED)

TYPE	EFFECTIVE PERIOD FROM	TO	RATE(%)	LOCATIONS	APPLICABLE TO
PRED.	05/01/99	04/30/02	41.2	On-Campus	All Programs
PROV.	05/01/02	UNTIL AMENDED	Use same rates and conditions as those cited for fiscal year ending April 30, 2002.		

*BASE:
Direct salaries and wages including all fringe benefits.

INSTITUTION:
University of Waterloo

AGREEMENT DATE: February 25, 1999

SECTION II: SPECIAL REMARKS

TREATMENT OF PAID ABSENCES:
Vacation, holiday, sick leave pay and other paid absences are included in salaries and wages and are claimed on grants, contracts and other agreements as part of the normal cost for salaries and wages. Separate claims for the costs of these paid absences are not made.

In accordance with HHS Grants Administration Manual, Chapter 6-150, no indirect cost is awarded on grants from the Department of Health and Human Services.

Treatment of Fringe Benefits: Fringe benefits applicable to direct salaries and wages are treated as direct costs.

Equipment means an article of nonexpendable, tangible personal property having a useful life of more than one year, and an acquisition cost of $1,000 or more per unit.

INSTITUTION:
University of Waterloo

AGREEMENT DATE: February 25, 1999

SECTION III: GENERAL

A. LIMITATIONS:
The rates in this Agreement are subject to any statutory or administrative limitations and apply to a given grant, contract or other agreement only to the extent that funds are available. Acceptance of the rates is subject to the following conditions: (1) Only costs incurred by the organization were included in its facilities and administrative cost pools as finally accepted: such costs are legal obligations of the organization and are allowable under the governing cost principles; (2) The same costs that have been treated as facilities and administrative costs are not claimed as direct costs; (3) Similar types of costs have been accorded consistent accounting treatment; and (4) The information provided by the organization which was used to establish the rates is not later found to be materially incomplete or inaccurate by the Federal Government. In such situations the rate(s) would be subject to renegotiation at the discretion of the Federal Government.

B. ACCOUNTING CHANGES:
This Agreement is based on the accounting system purported by the organization to be in effect during the Agreement period. Changes to the method of accounting for costs which affect the amount of reimbursement resulting from the use of this Agreement require prior approval of the authorized representative of the cognizant agency. Such changes include, but are not limited to, changes in the charging of a particular type of cost from facilities and administrative to direct. Failure to obtain approval may result in cost disallowances.

C. FIXED RATES:
If a fixed rate is in this Agreement, it is based on an estimate of the costs for the period covered by the rate. When the actual costs for this period are determined, an adjustment will be made to a rate of a future year(s) to compensate for the difference between the costs used to establish the fixed rate and actual costs.

D. USE BY OTHER FEDERAL AGENCIES:
The rates in this Agreement were approved in accordance with the authority in Office of Management and Budget Circular A-21 Circular, and should be applied to grants, contracts and other agreements covered by this Circular, subject to any limitations in A above. The organization may provide copies of the Agreement to other Federal Agencies to give them early notification of the Agreement.

E. OTHER:
If any Federal contract, grant or other agreement is reimbursing facilities and administrative costs by a means other than the approved rate(s) in this Agreement, the organization should (1) credit such costs to the affected programs, and (2) apply the approved rate(s) to the appropriate base to identify the proper amount of facilities and administrative costs allocable to these programs.

BY THE INSTITUTION:
University of Waterloo

(INSTITUTION)

B.C. Scott
Director
Research Finance

(SIGNATURE)

(NAME)

(TITLE)

(DATE)

BY THE COGNIZANT AGENCY
ON BEHALF OF THE FEDERAL GOVERNMENT:

DEPARTMENT OF HEALTH AND HUMAN SERVICES
(AGENCY)

(SIGNATURE)

Vincent J. Bamundo
(NAME)

DIRECTOR, DIVISION OF COST ALLOCATION
(TITLE)

February 25, 1999
(DATE) 0403

HHS REPRESENTATIVE: Regina Buttacavole
Telephone: (212) 264-2069

CALFED Proposal Title:

Contaminant-source control in the watershed: an evaluation of the *in situ* removal of mercury from groundwater using permeable reactive barriers (PRBs)

Amount requested: $208,235

Principal Investigator: Dr. David W. Blowes, Professor
Department of Earth Sciences
University of Waterloo
Waterloo, ON, Canada, N2L-3G1
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Collaborating Organizations:

Homestake Mining Company
Dean Enderlin, Senior Environmental Engineer
McLaughlin Mine, Lower Lake, CA

Geochimica, Inc. Mark Logsdon, Principal Geochemist, Ojai, CA

Ray Krauss Independent Consultant, Santa Rosa, CA

TRC Dr. Ian Hutchinson, Irvine, CA
Deems Padgett, Concord, CA

EXECUTIVE SUMMARY

The use of permeable reactive barriers (PRBs) for passive treatment of contaminated groundwater has been shown to be a viable cost- and technically effective alternative to conventional remedial technologies such as pump-and treat technology. PRBs are designed to intercept entire plumes of contaminated groundwater and typically consist of reactive material that has been installed in an excavated trench or cavity to replace original aquifer material. As groundwater flows through the reactive material, contaminants are degraded or removed within or down gradient of the PRB by one or a combination of physical, chemical or biological processes. In cooperation with the Homestake Mining Company, Lower Lake, CA, preliminary laboratory batch experiments have demonstrated the removal of mercury from groundwater using reactive materials suitable for use in a PRB system. Mercury is a common contaminant in the San Francisco Bay/Sacramento San Joaquin Delta Estuary and has several sources including discharges from natural springs and from anthropogenic mining and metal-refining facilities. This research proposal outlines a field-column study that will be undertaken at Homestake's Knoxville Mine Site. The project objectives are 1) to identify suitable reactive materials that can treat mercury in groundwater, 2) to identify processes that may limit the long-term effectiveness of the reactive material, and 3) to identify implications of the field-column testing for potential

use as a PRB system in the ground. The experiments will be conducted under groundwater flow conditions typical of the site, and with native site groundwater that contains dissolved mercury. This study will include a detailed analysis of the pore water in the columns including influent and effluent concentrations, mineralogical analysis of the reactive materials at completion of the experiments, and geochemical modeling of the waters. It is anticipated that a suitable reactive material or mixture will be identified that could be used in PRBs to remove mercury from groundwater.

The technology has the potential to provide excellent source-zone control at sites where mercury is being discharged from groundwater to surface water, and at sites where appropriate construction techniques can be applied. The technology offers the advantage of operating in a passive manner for years to decades, and would decrease operational and maintenance demands of active pump-and-treat systems and the associated above ground water treatment and control facilities.

The proposed project has both direct and indirect applicability to a number of the CALFED Bay Delta Programmatic Goals. In particular, this proposal provides the rationale and procedure for a field program to evaluate the potential for mercury discharges into the delta system and is directly applicable to CALFED water quality programmatic goals. As summarized in the *CALFED Bay-Delta Program, Water Quality Program Plan,* mercury levels of certain species of fish in the Delta are at sufficient concentrations to warrant fish advisories for human consumption. Data collected from this effort will provide the added benefit of additional quantitative data on groundwater mercury levels that can be used by other scientific efforts to evaluate the ecological impacts form mercury discharges. This may include human and ecological health risk assessments, including and evaluation of potential impacts to threatened and endangered aquatic species.

A. Project Description

1. Statement of the Problem

1a. Problem

The CALFED Bay-Delta Program and previous initiatives have identified mercury as a key contaminant that has a negative impact on the quality of water, sediments and terrestrial and aquatic habitats in the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary. The sources of mercury in the watershed, Estuary and Bay include discharges from natural springs and from anthropogenic mining and metal-refining facilities in the Central Valley. The quality of water and sediment throughout the watershed has been evaluated in the Draft Programmatic EIS/EIR Technical Appendix, Water Quality Program (CALFED), June 1999. The Appendix confirms the introduction of mercury from various sources within the watershed, and indicates the relative importance of current and former mining activities. Natural geothermal waters also may be a source, and it is likely that such geothermal waters are the late-stage manifestation of the hydrothermal flow systems responsible for the Late Tertiary mercury mineralization of the Coast Range zone. Where sources originate in the subsurface, and groundwater transport and discharge to surface water is the pathway for mercury introduction to the surface water in the watershed, groundwater control technologies could improve environmental management programs to minimize the release of mercury from these sites.

1b. Conceptual Model

Typically the control of plumes of contaminated groundwater has been achieved using active pump-and-treat systems. These require continuous inputs of energy, supervision, monitoring and maintenance, and also require that the recovered groundwater be treated and discharged within the strict terms of water-discharge permits. The use of permeable reactive barriers (PRBs) for the passive, *in situ* interception and treatment of contaminated groundwater has been demonstrated to be a viable and economical alternative to conventional active remedial technologies such as pump-and-treat in many environmental control and management programs. PRBs are designed to intercept entire plumes of contaminated groundwater and typically consist of reactive material that has been installed in an excavated trench or cavity to replace original aquifer material. As groundwater flows through the reactive material, contaminants are degraded or removed within or down gradient of the PRB by one or a combination of physical, chemical or biological processes. PRBs have the potential to remove mine-waste effluent, electroactive metals, and nutrients such as phosphate and nitrate, and industrial organic contaminants from groundwater. PRBs offer the advantage of removing or stabilizing the contaminants in the groundwater in close proximity to their source, potentially without the point-source complications of an engineered reactor or other conventional water-treatment system. Experience gained through field and commercial scale demonstrations and applications has confirmed that PRBs can achieve appropriate removal of contaminants from groundwater prior to its discharge to receiving surface water or arrival at another critical-receptor point.

Preliminary laboratory investigations conducted by the University of Waterloo (UW) in cooperation with Homestake Mining Company have indicated very good prospects for the removal of mercury from groundwater at the Knoxville site using reactive materials in a PRB

systems. The initial laboratory work was performed using site groundwater from the Knoxville Mine. Further assessment and demonstration of the groundwater-treatment technology is warranted prior to its application at the field-scale. This proposal to the CALFED Bay-Delta Program seeks funding to extend the laboratory bench-scale tests to evaluate the removal of mercury from groundwater under dynamic flow conditions in field columns. The field columns will be set up at in a small temporary building at the Knoxville Mine, and will operate using groundwater containing elevated concentrations of mercury. The columns are approximately 40 cm (1.25 ft) in length and 5 cm (2in) in diameter. Flow through the column will be of the order of 0.5 L (0.12 gallons) per day. The test site will be situated within the catchment of active water control and management facilities at the site. The results of the column tests will help calibrate working hypotheses regarding the potential success of PRB technology for *in situ* treatment of mercury-contaminated groundwater to levels that are acceptable from a human and ecological health perspective. If the field column tests are shown to be successful, a subsequent proposal to CALFED or another program will seek support for a field-scale PRB demonstration.

1c. Hypotheses Tested

The *in situ* treatment technologies for electroactive metals, such as chromium, arsenic, selenium, uranium and mercury, were conceived and developed at UW. The PRB technology for the treatment of metal and inorganic contaminants in groundwater has been patented (Canadian Patent Number 2,062,204 (July 7,1998); U.S. Patent 5,362,394 (Nov. 8,1994), U.S Patent 5,514,279 (May 7,1996)). A European Patent application (#92103559.8) was filed on March 12, 1992. UW holds these patents.

PRB technology has been applied to the treatment of metals and other inorganic contaminants in groundwater. A zero-valent iron barrier was installed at Elizabeth City, NC, for the removal of chromium (VI) and several chlorinated solvents in 1996. The PRB was 45 m in length, 0.6 m in thickness and 6 m in depth and has provided excellent treatment of Cr (VI) since installation. Cr (VI) concentrations have decreased from as much as 10 mg/L in the influent groundwater to less than 0.01 mg/L within the PRB, and the system continues to provide excellent groundwater system four years after its installation (Blowes et al. 1997; 2000abc).

PRB technology can also be used to intercept and treat acid-mine drainage (AMD) in groundwater. The reactive material contains organic carbon, and is designed to promote sulfate reduction and the subsequent precipitation of metal sulfide minerals. The prototype barrier was installed in an aquifer affected by drainage water derived from a sulfidic mine tailings impoundment in the Sudbury area, Ontario. The wall, which was installed in August 1995, was 15 m in length, 4 m in thickness , and averaged 3.6 m in depth. The reactive media was a mixture of organic matter and carbonate containing gravel, and was bounded on the up-gradient and down-gradient faces of the wall by coarse sand. The wall has been successful in promoting microbially mediated sulfate reduction, and the subsequent precipitation of iron and other metal sulfides. In groundwater within the wall, sulfate concentrations decreased from 2400 to 4600 mg/L to 200 to 3600 mg/L, iron concentrations decreased from 250 to 1300 mg/L to 1 to 40 mg/L, pH increased from 5.8 to 7.0 and alkalinity increased from less than 50 mg/L as $CaCO_3$ to 600 to 2,000 mg/L. The capacity of the groundwater to generate acidity upon discharge to surface water or ground surface has been significantly decreased (Benner et al. 1997; 1999).

The first commercial, field-scale PRB system was installed in 1994 at an industrial site (Interstil, Inc.) in Sunnyvale, CA (Yamane et al. 1995). The PRB system was installed to treat chlorinated volatile organic compounds (VOCs) in groundwater by reductive dechlorination. The treatment zone, which contained zero-valent iron, was approximately 6 m (20 ft) in length, 1.2 m (4 ft) thick, and approximately 12 m (40 ft) in depth. Groundwater flow was directed to the treatment zone by two lateral low-permeability slurry-wall barriers. The PRB replaced a previously existing pump-and-treat system and the above ground treatment and water discharge facilities. The PRB has continued to achieve remedial objectives, which are California Department of Health Services Maximum Contaminant Levels (MCLs), and has operated in a passive mode for more than five years. It is apparent that PRB systems can operate successfully for years to ten years or more with very modest requirements for maintenance. Ultimately, however, there may be a need to rejuvenate or replace the reactive media in the PRB system.

At the laboratory scale, excellent removal of arsenic, selenium and uranium, in addition to chromium, has been achieved in dynamic flow-through columns. The columns have typically been operated for periods of several months using groundwater from the sites of concern. The site water has commonly been amended prior to use to increase the concentrations of the contaminants of concern. Although a variety of potential reactive media have been evaluated, zero-valent iron has generally provided the greatest degree of metal removal. The metals, which can be removed to concentrations of parts per billion or less, are typically present at concentrations below their respective MCLs in effluent from the laboratory- and field-scale systems. PRB systems to remove uranium have been installed at three U.S. Department of Energy facilities. Field-scale systems are being considered at other industrial and mine sites for the treatment of arsenic and selenium in groundwater.

Preliminary laboratory batch testing at UW has indicated that the removal of Hg from solution to very low levels is sufficiently rapid using readily available reactive media to warrant further bench-scale evaluation of the PRB technology for remediation of mercury-contaminated groundwater. UW conducted two series of static batch tests to evaluate the removal of mercury from solution in the presence of zero-valent iron. The testing was conducted using groundwater from the Knoxville Mine, which is situated in the California Coast Range. The water was amended with an inorganic mercury salt to increase mercury concentrations prior to testing. Initial concentrations of mercury were several tens of mg/L in one series of tests, and of the order of 0.2 mg/L in the other. The solid materials in the reaction vessels consisted of a 50:50 mixture of zero-valent iron and aquifer sand, and the mass of iron was approximately 0.1 of the mass or volume of water. In the high-concentration tests, Hg concentrations decreased from several tens of mg/L to approximately 0.1 mg/L within 3 to 6 days and to less than 0.03 mg/L within tens of days. In the second series of tests, the concentration of Hg decreased from approximately 0.2 mg/L to approximately 0.02 mg/L within 4 to 6 hours. Geochemical modeling suggested that mercury is removed from solution in conjunction with the precipitation of other mineral phases, most likely ferrihydrite or related iron oxyhydroxides. Further laboratory testing has confirmed that removal of mercury to concentrations of less than 0.0005 mg/L can be achieved in the batch reaction vessels (Figure 1).

1d. Adaptive Management

The proposed project will evaluate the potential applicability of PRB technology for the removal of mercury from groundwater. If applicable, the technology could ultimately be adapted to reduce discharges of mercury from groundwater to surface water at key sites in the watershed. This is an important goal (Sediment and Water Quality) of the CALFED Ecosystem Restoration Program. The project will be undertaken in the field at a site within the watershed. The primary objective of the project is to evaluate the performance of the PRB technology at this targeted but representative research scale, and to use the results as appropriate to develop plans for subsequent demonstration or field-scale restoration systems.

1e. Educational Objectives

The field-column evaluation program is intended to indicate the viability of the use of PRBs for the removal of mercury from groundwater prior to its discharge to surface water. The results of the project will form the basis of presentations at scientific meetings by various participants within a one-year period following the start of the project. Meetings in California, and the Bay and watershed area in particular, will be selected. The project and results may also form the basis for scientific, peer-reviewed publications, but it can be anticipated that such publications would not appear for at least a year after the completion of the field-column project. The project will also be reported in a format suitable for inclusion in a local community newspaper. The implications of the project to the environmental management of mercury sources in the watershed will be incorporated in this report. Public education and interaction with the local community will form an important component of any subsequent proposal for a demonstration or field-scale PRB.

2. Proposed Scope of Work

2a. Location and Geographic Boundaries

The Knoxville Mine is located in Lake County, within the Putah Creek Watershed, one mile southwest of the McLaughlin Mine (UTM Zone 10, N 4298061, E 556260, Figures 2 and 3). Putah Creek drains to the Yolo Basin via Lake Berryessa, but the Mine is located to the west of the Yolo Basin Ecological Management Zone.

2b. Approach

Field-Column Studies:

Objectives:

The overall objective of the proposed field column-testing project is to assess the applicability of PRBs for removing dissolved mercury and other metals from groundwater at the Knoxville Mine Site, Lake County, California. The specific objectives of the project are to:

1. Evaluate reactive mixtures for the removal of dissolved mercury and other metals from the site water under dynamic flow conditions. Preliminary laboratory batch tests indicate that mercury can be removed by surface reactions of reactive media such as iron. The cost of iron is quite high, so the use of other less expensive reactive materials in mixtures

with iron will be evaluated with respect to their mercury-removal capabilities and biogeochemical side effects. An important aspect of the evaluation will focus on the mercury-removal mechanisms. In particular the columns will be monitored in a manner to facilitate the determination of the form of mercury in the reactive materials through detailed chemical analyses and geochemical modeling. The potential for the generation of methylated mercury compounds within the reactive materials will also be explored.

2. Identify chemical and physical processes that may limit the long-term effectiveness of the treatment system. In particular issues related to the effect of pH changes arising from the interaction between the site groundwater and the reactive media will be evaluated. The influence of microbially mediated sulfate reduction reactions, which may occur within the reactive mixtures, will also be assessed. The precipitation of secondary minerals such as carbonates, iron oxyhydroxides, and metal sulfides in the PRB will also be evaluated because these may influence the porosity, permeability, reactivity and potential longevity of a PRB in the field.

3. Identify the implications of the results of the field-column testing to the potential use of PRBs in the control and remediation of groundwater contaminated with mercury. If the prospects for successful remediation using PRBs continue to look promising, a proposal will be prepared for CALFED or other agency or company to fund the installation and monitoring of a field-scale PRB system.

Selection of the Reactive Mixture:

A suitable reactive substrate for a PRB must: 1) be sparingly soluble; 2) react with the contaminant on time scales less than the residence time of the groundwater within the barrier; 3) be inexpensive; 4) not produce toxic by-products; and 5) not decrease the permeability of the PRB or formation. Previous experiments at UW indicate that elemental iron and organic carbon may meet all of these requirements.

Flow-Through Column Experiments:

Laboratory batch and column test procedures were used to evaluate the applicability of the zero-valent iron for groundwater remediation at the Elizabeth City site (Blowes et al., 1997a,b). Similar column procedures are proposed here to evaluate the effectiveness of these processes for removal of dissolved mercury and other metals in groundwater from the Knoxville Mine Site. Column tests will be performed using reactive materials from commercial suppliers. The purposes of the tests are:

1. To determine if zero-valent iron and mixtures of iron with organic carbon and/or aquifer sand promote the removal of mercury and other metals under the geochemical conditions present in the site groundwater. Five columns will be tested. The reactive materials in the columns will include:
    - 100% commercially available iron (Chicago).
    - 100% commercially available iron (California).
    - 50% iron and 50% silica sand.
    - 50% iron and 50% compost (organic carbon).
    - 100% commercially available iron (Chicago) with influent concentrations of approximately 10 mg/L Hg total.
2. To determine the mechanisms and consequences of the mercury-removal processes. The column with the high-concentration influent will improve the

prospects for analysis of the mercury-solid systematics in comparison to the lower concentration influent associated with the ambient site groundwater.

3. To determine changes in the major ion chemistry of the water as it passes through the reactive materials, and to assess the effects of precipitation processes occurring within the reactive materials.
4. To evaluate the long-term sustainability of the removal processes.
5. To assist in the development of design criteria for construction of on-site *in situ* treatment systems.

Materials and Methods:

The field-column testing will occur adjacent to a groundwater monitoring well at the site. The columns will be housed in a small shed, and operated on top of a small laboratory bench. The shed will provide protection for the columns, and also serve as a field laboratory. The shed will be serviced with domestic AC electric current.

The column apparatus, shown schematically in Figure 4, consists of a plexiglass tube 40 cm long by 5.1 cm internal diameter, and fitted with influent and effluent end plates. The feed solution will be groundwater that will be delivered to the influent end of the column by a low-flow peristaltic pump. The influent for one column will be spiked with high concentrations of mercury (approximately 10 mg/L). This water will need to be stored in a 20 L glass vessel and maintained in an anaerobic state to minimize the precipitation of dissolved iron or other compounds prior to its introduction to the column. Samples of influent and effluent solutions can be collected from sampling cells at the respective ends of the column. Separate columns will be set up to each of the five reactive mixtures, and will be tested simultaneously.

The initial velocity of water flow through the columns will likely be of the order of one column pore volume per day. This represents a groundwater velocity of approximately 40 cm (1.33 ft) per day. The velocity may subsequently be changed, depending on the degree of contaminant treatment being achieved and an indication of actual groundwater flow velocities at the site.

2c. Monitoring and Assessment Plans

Samples will be collected from the influent and effluent lines 8 times at the initial flow rate before a decision to modify or maintain the flow rate will be made. Eh, pH and alkalinity will be measured in the field laboratory immediately following the collection of each sample. All samples will be analyzed for dissolved metals including mercury, major cations, and major anions. Profiles of the detailed water chemistry throughout each of the columns will be determined at least once while the initial flow rate is being used, and at later times during the experiment Supplementary sampling may also be conducted to assess specific details of mercury chemistry.

The proposed column tests will be run for at least 50 pore volumes. The proposed sampling frequency for the influent and effluent solutions will be every five pore-volumes during the test. The purpose of sampling the influent water is to provide information to determine whether geochemical changes have taken place in the influent water over time. The effluent samples will be collected and analyzed to assess the removal efficiency for dissolved contaminants, as well as to provide geochemical information to aid in the interpretation of the removal mechanisms.

Monitoring of the columns will include a complete record of flow, and documentation of the geochemical changes in water chemistry with time within the reactive media. As noted, Eh, pH and alkalinity of water samples will be measured in the field at the time of sample collection. Chemical analyses of water samples will include anions by Ion Chromatography (IC), metals and cations by Inductively Coupled Plasma (ICP-AES and ICP-MS), and mercury species (Hg (0), Hg (I), Hg (II), methyl and dimethyl Hg). The mercury analyses will be conducted by Frontier Geosciencs, Inc. (Seattle, WA), and the anion, cation and metal analyses will be performed at both UW and Frontier.

Solid-phase mineralogical assessment of the column material will be conducted at the completion of the column tests. This will be conducted at UW using traditional mineralogical analysis methods (reflected light microscopy) in combination with surface-analysis methods (secondary electron microscopy-SEM; energy-dispersive X-ray analysis-EDX; electron probe microanalysis-EPMA; X-ray photoelectron spectroscopy-XPS; Raman spectroscopy; and Auger electron spectroscopy-AES).

2d. Data Handling and Storage

Data will be stored in digital and hard-copy form. Data will include characteristics of the reactive media, column water flow records, and all analytical results. The performance of the columns will be assessed with specific reference to their ability to remove mercury from water. Furthermore, geochemical speciation calculations will be conducted with the water chemistry data collected from the column tests to provide information to aid in the interpretation of the dissolved metal removal mechanisms. The calculations will be made using a geochemical speciation/mass transfer code such as MINTEQA2 (Allison et al., 1990). The MINTEQA2 data base will be modified by adding more recent thermodynamic data reported in the literature (e.g. Nordstrom *et al.*, 1990; Ptacek et al., 1994). The mineral saturation indices and solid phase monitoring will allow us to construct a feasible set of geochemical reactions that will occur within the reactive barrier as well as down gradient from the barrier. The geochemical evolution of the dissolved and solid-phase constituents of the treatment columns will also be evaluated using a reactive transport and groundwater flow model (MIN3P) (Blowes et al. 2000c). This model will be used to simulate the observed chemical changes in the column, and to assist in assessing the longer-term performance and treatment potential of the columns. This type of analysis is necessary to provide some predictive capability for use of the technology in field systems.

2e. Expected Products/Outcomes

Projects similar to that proposed here have been used to evaluate the removal of electroactive metals from groundwater prior to the installation of effective field-scale PRB systems. The preliminary laboratory results for the removal of mercury from Knoxville Mine groundwater by reactive iron suggests that the field-column program will demonstrate that PRB technology can remove mercury from groundwater under dynamic flow conditions. Furthermore, the program has sufficient scope to confirm that the removal processes convert mercury to reduced, stable and low-solubility solid phases and that the reaction processes are rapid and can be sustained for long periods of time. The results of the study, when used in conjunction with reactive solute transport modeling, can be used to define design parameters for the Knoxville Mine or other sits in the region. This information is required to support decisions regarding the installation of demonstration or full-scale PRB systems for mercury treatment in groundwater. The proposed

project has a realistic schedule, and can achieve its stated goals. In the longer term, PRB technology may provide an effective approach to the control of mercury discharge to surface waters, an important objective of the CALFED Program. The targeted research described in this proposal is a necessary step to evaluate potential applicability of this environmental remedial technology.

2f. Work Schedule

The column tests and supporting field and analytical work will be conducted over a one-year period following approval of the project. This includes allowances for approximately: 2 months to set up the columns; 3 months to complete the column tests on site; 4 months to complete the chemical analyses and supporting laboratory tests, mineralogy and geochemical modeling; and 3 months to complete the final report and summarize the implications of the program for a field-scale PRB system.

2g. Feasibility

The proposed project builds on previously demonstrated technology evaluation techniques in combination with specific and promising results for the removal of mercury from groundwater. The project has an experienced and highly qualified scientific and technical implementation staff and advisory team. The project has received a strong commitment from Homestake Mining Company that includes the necessary access to the Knoxville Mine field site and the provision of supporting infrastructure. The project will take place entirely on a private facility, avoiding the need for government notification. The project is essentially non-intrusive and does not require major construction or facilities. The schedule is intense but realistic. Because it does not rely on external contractors, the project can be initiated with no delay following notification of award. The field-column project has no potential negative environmental consequences, and will use approximately 500 L (125 gallons) of site groundwater during the three months of column use. Furthermore, the team is not restricted in its access to the patented PRB technology for the purpose of this project.

A. Applicability to CALFED ERP Goals and Implementation Plan and CVPIA Priorities

1. ERP Goals and CVPIA Priorities

The mission of the CALFED Bay-Delta Program is to develop a long-term plan to restore ecological health and improve water management of the Bay-Delta System. The proposed project focuses on bench-scale testing to evaluate a potential corrective measure to reduce mercury discharges to the watershed in close proximity to the source of the contaminants. The project specifically targets Strategic Goal 6 (Sediment and Water Quality) of the Ecosystem Restoration Program. Through the reduction of releases of mercury and other contaminants, water and sediment quality can be improved, and the potential negative impacts on human and ecological health can be decreased.

The proposed research project directly responds to technical and policy information needs identified in the Draft Programmatic EIS/EIR Technical Appendix on Water Quality (Appendix 4) for the CALFED Delta-Bay Program. The proposed project has both direct and indirect applicability to a number of the CALFED Bay Delta Programmatic Goals. In particular, this proposal provides the rationale and procedure for a field program to evaluate the potential for mercury discharges into the delta system and is directly applicable to CALFED water quality programmatic goals. As summarized in the *CALFED Bay-Delta Program, Water Quality Program Plan,* mercury levels of certain species of fish in the Delta are at sufficient concentrations to warrant fish advisories for human consumption. Data collected from this effort will provide the added benefit of additional quantitative data on groundwater mercury levels than be used by other scientific efforts to evaluate the ecological impacts form mercury discharges. This may include human and ecological health risk assessments, including and evaluation of potential impacts to threatened and endangered aquatic species.

The proposed program would address:

- Sources and transport of mercury. A source-control technology will be evaluated at the bench-scale in the field.
- Transformations of mercury that are relevant to boiavailability. The removal of mercury from groundwater prior to its discharge to surface water will reduce the influx of mercury to the watershed. The fate of mercury in the PRB systems remains to be confirmed, but there is good evidence that a very significant portion of the mercury within the treatment systems will not be bioavailable.
- Approaches to cost-effective treatment that controls mercury concentrations at or very close to their sources. This is an important premise influencing the development and testing of PRB technology.

2. Relationship to Other Ecosystem Restoration Projects

The University of Waterloo and other members of the project team are new to the CALFED Program, having been brought recently into the process by Homestake Mining Company. We would be pleased to evaluate how this field test could be coordinated with other ERPs as data on the PRB-technology's performance is generated.

3. Requests for Next Funding Phase (N/A, Not Applicable)

4. Previous Recipients of CALFED or CVPIA funding (N/A)

5. System-wide Ecosystem Benefits

Although the project deals with targeted bench-scale evaluation of PRB technology using field columns, the technology does exhibit excellent promise for the control and removal of mercury and other metals from groundwater in close proximity to the source of contamination. The technology could prove to be broadly applicable to reducing the loading of mercury and other metals to the surface water and sediments within the Delta-Bay system. This could improve the water and sediment quality, and decrease negative impacts to human and ecosystem health.

B. Qualifications:

The University of Waterloo, in co-operation with Homestake Mining Company, Geochimica, Inc., Ray Krauss and TRC, will conduct the field column-testing project. This team has previously worked together on the preliminary laboratory testing to examine the potential removal of mercury from groundwater using reactive materials. The Principal Investigator will be Dr. David Blowes. Dr. Blowes is a Member of the Institute for Groundwater Research and Professor in the Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, Canada. Dr. Blowes' research interests focus on the fate of inorganic contaminants in groundwater flow systems and the development of passive geochemical systems for remediation of contaminated groundwater. He holds six patents related to remediation techniques for contaminated waters. He has worked for more than 20 years on projects pertaining to the occurrence, fate and remediation of contaminants associated with mining facilities. He has been an active participant on more than 20 projects in the past five years dealing with the in situ treatment of groundwater containing metals and other inorganic contaminants. He was the Principal Investigator for the PRB installed to treat acid-mine waters in the Sudbury area in 1995 and for the chromium-treatment PRB installed in co-operation with the U.S. Environmental Protection Agency in Elizabeth City, NC, in 1996. His research staff, several of who have advanced degrees in the environmental sciences, also have extensive experience PRB-related projects.

Dean Enderlin is the Senior Environmental Engineer at Homestake Mining Company's McLaughlin Mine, Lower Lake, CA. He has 15 years experience in the mining industry with Homestake and is currently head of the Environmental Department at the McLaughlin Mine. Mr. Enderlin has oversight responsibility for the environmental management program at the Knoxville Mine. He has an extensive knowledge of the environmental monitoring and water treatment initiatives that have been implemented.

Mark Logsdon is the Principal Geochemist at Geochimica Inc., Ojai California. He is a hydrogeochemist with more than 25 years experience in environmental geochemistry, specializing in the metals mining research field. Recent work has focussed on mining-related issues in Central California.

Raymond Krauss, is an independent consultant from Santa Rosa, CA, and is currently employed by Homestake in a consulting capacity. A former Environmental Department head at the McLaughlin Mine, he brings many years experience to the team on issues related to environmental management and compliance.

The TRC Consultants are Dr. Ian Hutchinson, Denver, CO and Deems Padgett, Concord, CA. Dr. Hutchison is Senior Vice-President at TRC and is TRC's national director for mining projects. Mr. Padgett is currently a Project Director at TRC's Northern California office, and has completed mine reclamation projects, which included water quality programs to monitor, detect and mitigate acid rock drainage and eliminate recurring impacts to local watersheds.

University of Waterloo personnel will perform the field column experiments tests at the Knoxville Mine, CA. During this past decade, UW has conducted extensive, laboratory-based research to assess the degree and mechanisms of remediation for various electroactive metals and radionuclides. UW will employ similar techniques to those used in the laboratory to evaluate the performance of the field columns. Selected sample analyses, including mineralogical and surface characterization, and geochemical modelling will be conducted through UW. The UW Office of Research will provide contractual and financial administrative services.

Frontier Geosciences Incorporated (Seattle, WA) and UW will provide analytical chemical services.

Homestake Mining Company will provide:

- access to the Knoxville Mine site;
- provision of electrical services to the field laboratory building,;
- reduced costs for lodgings for field staff; and
- data and information pertinent to the occurrence and fate of mercury in the subsurface generated in the years (decades) in which environmental management and monitoring programs have been in place at the Knoxville Mine.
- A representative (Dean Enderlin, Sr. Environmental Engineer) on the project steering committee.

The remaining participants (Geochimica, Inc., R. Krauss and TRC) have extensive experience dealings with the Knoxville Mine through their provision of environmental, geohemical and hydrogeological consulting services to Homestake. Each will also serve on the steering committee for the project.

C. Proposed Budget (Costs are in U.S. $)

Column Tests to Assess Removal of Mercury and Other Metals

Task 1. Evaluate reactive mixtures for the removal of dissolved mercury from site water.
Task 1a. Column experiments at Knoxville Mine.
Task 1b. Analyze and evaluate data.

Task 2. Identify chemical and physical processes affecting the treatment system.
Subtask 2a. Geochemical modelling of column samples.
Subtask 2b. Mineralogy of reactive materials.

Task 3. Identify implications from column testing for use of PRBs in remediating dissolved Hg.
Subtask 3a. Geochemical modelling.

Task PM. Project management.

A. Salaries (University of Waterloo)

1.	Principal Investigator (D. Blowes) (3*$1,000 Task 1,2,3 + $1,500 Task PM)	4,500
2.	Research Hydrogeologist (D. Smyth 4 months @ $3,750/month) (2 months Task 1a,b + 2 months Task PM)	15,000
3.	Research Hydrogeochemist (5.3 months@$3,000) (2 months Task 1a,b + 2.5 months Task 2a,b + 0.5 months Task 3 + 0.3 months Task PM)	16,000
4.	Technical Support (4 months@$2,000) (4 months Task 1a)	8,000
	Salary Total (A)	**$43,500**

B. Benefits on A (15%) **$6,525**

C. Overhead (41.2% on Total of Salaries + Benefits (A+B)) **$20,610**

D. Field Expenses, Materials and Supplies

Task 1a – Column Studies

1.	Shed/ Field Laboratory Building	3,000
2.	Columns – 5 columns @ $300	1,500
3.	Pump – 1 variable speed multi-channel pump	2,000
4.	Eh/pH Meters – 2 meters at $500	1,000
5.	Vehicle - rental	3,600
6.	Freight and courier charges	1,000
7.	Air Fares	7,000
8.	Per Diem/ Living Allowance	7,500
	Sub-total	$26,600

Consumables and Supplies	
Task 1. ($1,500 Task 1a + $400 Task 1b)	1,900
Task 2. ($400 + $50 Task 2a + $100 Task 2b)	550
Task 3. ($400 + $50 Task 3a)	450
Sub-total	$2,900
Computer ($100 Task 1b + $450 Task 2a + $450 Task 3a)	$1000
Communications (3*$100 Task 1,2,3 + $200 Task PM)	$500
Total (D)	**$31,000**

E. Analytical

Task 1b – Data Analysis		
Frontier GeoSciences Inc		
1.	Hg (0), Hg (II) 160 samples @ $110	17,600
2.	Methyl/Dimethyl Hg 80 samples @ $285	22,800
3.	ICP-MS 160 samples @ $60	9,600
University of Waterloo		
4.	Ion Chromatography, ICP-AES, AA (160 samples @ $60)	9,600
	Subtotal	$59,600
Task 2b.	Mineralogical and surface characterization	$35,000
	Total (E)	**$94,600**

F. Meetings (Task PM -Project Management):

1.	Geochimica	2,000
	Krauss	2,000
	TRC	2,000
	Homestake	0
	Sub-total	$6,000
2. UW:	Air Fares	4,000
	Hotel	1,200
	Per Diem	400
	Vehicle/ Miscellaneous	400
	Sub-total	$6,000
	Total (F)	**$12,000**

Total Field-Column Tests and Supporting Services	**$208,235**

Table 1. Annual and total budget for proposal "In situ removal of mercury from groundwater using permeable reactive barriers (PRBs)".

				Subject to Overhead				Exempt from Overhead			
Year	Task	Task Description	Direct Labor (months)	Salary	Benefits	(41.2% - salaries and benefits)	Travel	Supplies & Expendables	Service Contracts (Analyses)	Equipment Purchase	Total Cost
Year 1	Task 1	Evaluate reactive mixtures for removing Hg from groundwater		$1,000	$150	$473.80		$100			$1,724
	Subtask 1a	Column experiments	6	$14,750	$2,213	$6,988.55	$19,100	$4,000		$5,000	$52,051
	Subtask 1b	Analyze and evaluate data	2	$6,750	$1,013	$3,198.15	$0	$500	$59,600		$71,061
	Task 2	Identify chemical and physical processes affecting treatment		$1,000	$150	$473.80		$500			$2,124
	Subtask 2a	Geochemical modelling	2	$6,000	$900	$2,842.80		$500			$10,243
	Subtask 2b	Mineralogical and surface characterization	0.5	$1,500	$225	$710.70		$100	$35,000		$37,536
	Task 3	Identify implications from column test to PRB use with Hg		$1,000	$150	$473.80		$500			$2,124
	Subtask 3a	Geochemical modelling	0.5	$1,500	$225	$710.70		$500			$2,936
	Project Management	Project management and team meetings	2	$10,000	$1,500	$4,738.00	$12,000	$200			$28,438
Total Cost Year 1			13	$43,500	$6,525	$20,610	$31,100	$6,900	$94,600	$5,000	$208,235
Total Project Cost				$43,500	$6,525	$20,610	$31,100	$6,900	$94,600	$5,000	$208,235

C. Local Involvement

There will be little demand for the use of local contractors during the implementation of the field-column testing project. The materials that are required for the field laboratory structure will be purchased locally. The project will be undertaken with the prominent participation of Homestake Mining Company and its staff. In addition to Homestake, the collaborators on the project other than the University of Waterloo have a strong local presence.

If the results of the field-column project are promising, demonstration or full-scale PRB systems may be installed in the watershed at a future date. Although the location, terms or funding for these PRB systems would need to be established, there may be significant opportunities for the participation of local contractors and companies to participate on these projects.

D. Compliance with Standard Terms and Conditions

The University of Waterloo agrees to comply with the standard terms and conditions of the CALFED Program. The University is also obligated to abide by the laws of Canada and the Province of Ontario.

E. Literature Cited

Allison, J.D., D.S. Brown and K.J. Novo-Gradac, 1990. MINTEQA2/PRODEFA2, a geochemical assessment model for environmental systems: User's manual., Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Athens GA.

Benner, S.G., D.W. Blowes and C.J. Ptacek, 1997. A full-scale porous reactive wall for prevention of acid mine drainage. Ground Water Monitoring and Remediation, Vol. 17, (4), pp. 99-107.

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Ptacek, C.J. and D.W. Blowes, 1994. Influence of siderite on the geochemistry of inactive mine tailings impoundment. Environmental Geochemistry of Sulfide Oxidation (C.N. Alpers & D.W. Blowes, eds.), Am. Chem. Soc. Symp. Series 550, 172-189.

Yamane, C.L., S.D. Warner, J.D. Gallianatti, F.S. Szerdy, T.A. Delfino, D.A. Hankins, and J.L. Vogan, 1995. Installation of a subsurface groundwater treatment wall composed of granular zero-valent iron (Extended Abstract). Symposium on Contaminant Remediation with Zero-Valent Metals. 209th National Meeting of the American Chemical Society, Division of Environmental Chemistry, Anaheim, CA, 2-7 April 1995, pp792-799.

List of Figures

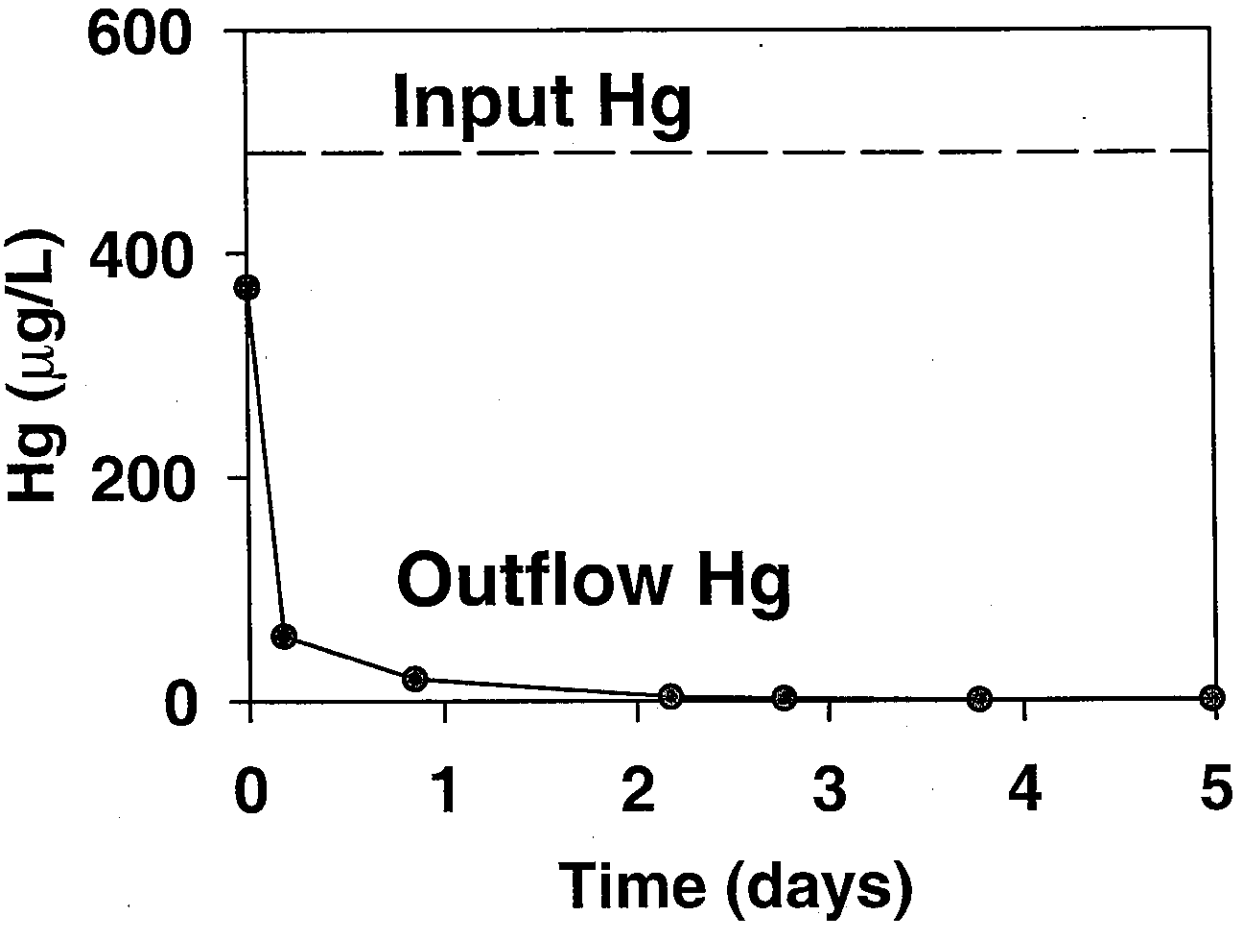

Figure 1. Batch test results showing the removal of mercury from Knoxville site groundwater using zero valent iron as the reactive material. In this preliminary experiment, the groundwater was spiked with additional mercury to increase the concentration to 490 µg/L Hg.

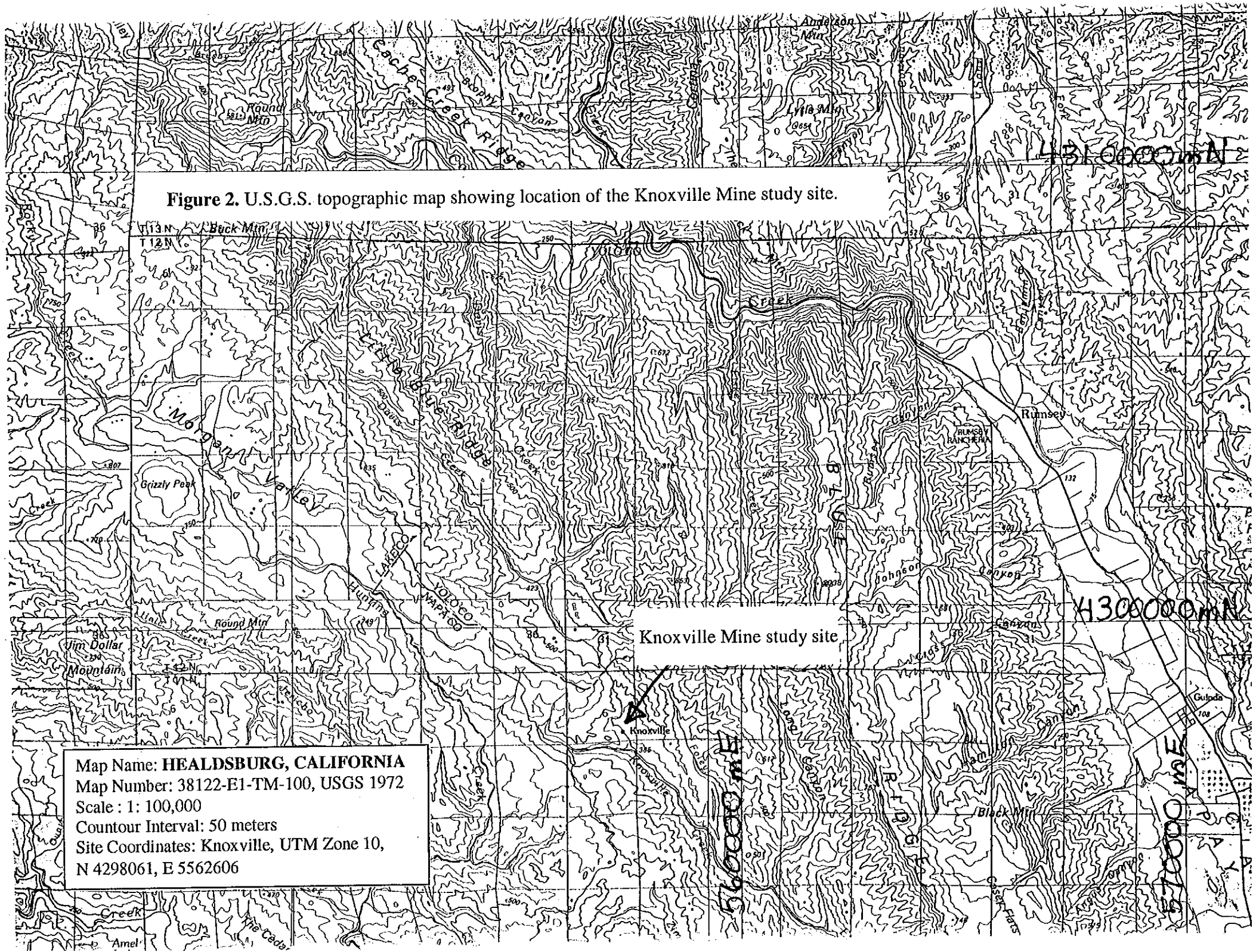

Figure 2. U.S.G.S. topographic map showing location of the Knoxville Mine study site.

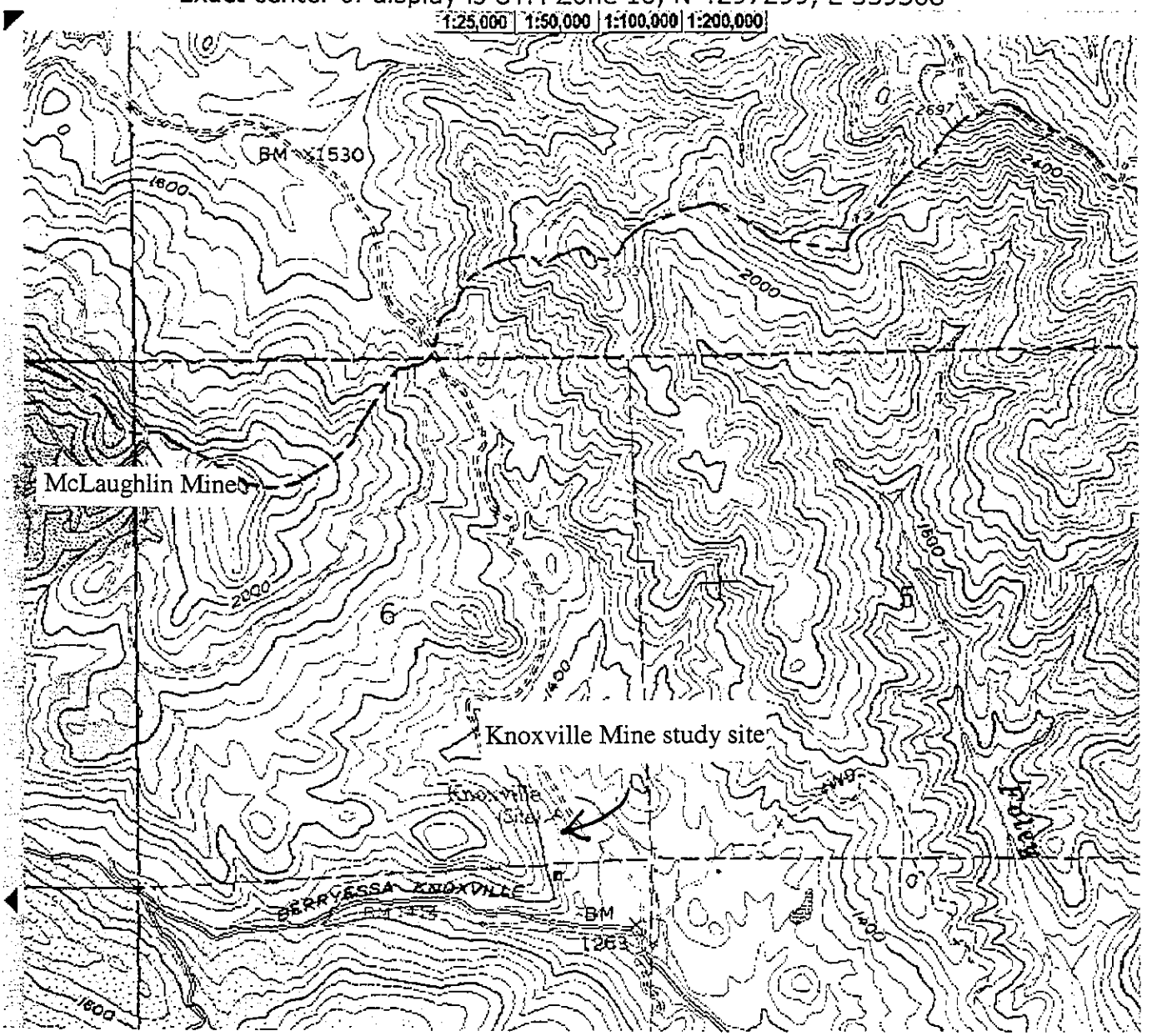

Figure 3. Topographic map showing location of Homestake Mining Company's Knoxville and McLaughlin Mines (Scale 1:25,000) (www.topozone.com).

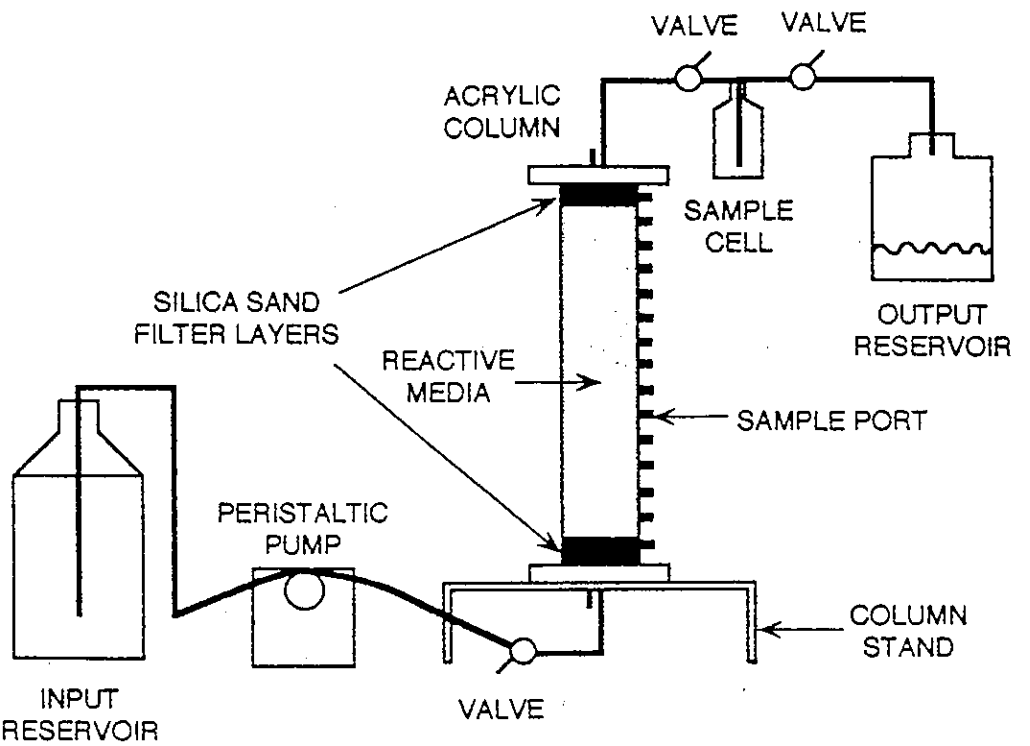

Figure 4. A schematic diagram of the column-testing apparatus.

GEOCHIMICA

5 May 2000

CALFED Bay-Delta Program

Re: Letter Of Professional Support For Research Proposal, "Contaminant-Source Control In The Watershed: An Evaluation Of The In-Situ Removal Of Mercury From Groundwater Using Permeable Reactive Barriers (PRBs)"

To Whom It May Concern:

My name is Mark J. Logsdon. I am a hydrogeochemist with more than 25 years experience with environmental geochemistry, particularly associated with metals mining. I have worked on more than 175 mining projects across the United States and Canada and in Mexico, South America, Europe, Africa, Indonesia, Phillipines, and New Zealand. During the last fifteen years, I have been involved with a variety of mining-related evaluations in central California, for mining companies, the Central Valley Regional Water Quality Control Board, and in support of citizens groups. I have followed the broad CALFED activities, as well as specific research by the University of California at Davis and the U.S. Geological Survey. In addition, I am familiar with the geochemical and hydrological principals and the literature on empirical case studies of the use of permeable reactive barriers (PRBs) to remove metals (and other contaminants) from ground water.

The origins, fate and management of mercury in the California Coast Ranges is a matter of local impact, but also is of regional and even national significance because of potential impacts on the Sacramento Delta and San Francisco Bay. Available data shows that there are multiple origins of mercury in the system, but it is clear that in many areas ground water is a significant transport pathway.

The proposed research project directly responds to technical and policy information needs identified in the Draft Programmatic EIS/EIR Technical Appendix on Water Quality (Appendix 4) for the CALFED Bay-Delta Program. The proposed work would address:

- Sources and transport of mercury;
- Transformations of mercury that are relevant to bioavailability;
- Approaches to cost-effective treatment that controls mercury concentrations at or very close to their sources.

Geochimica Inc., Consultants in Geochemistry
Tel: (805) 640-8697 206 North Signal Street, Suite M, Ojai, California 93023 Fax: (805) 640-9918

The technical basis for the PRBs has a sound and proven hydrological and geochemical foundation. The method has been used successfully for other redox-active metals in ground water, and there are site-specific data at bench scale to show that it may be effective for mercury in the Coast range environments, too. The technical team presenting the proposal are eminently qualified by training and experience, including direct experience with the technology and site-specific background. The proposal's emphasis on source control in a watershed framework is especially well posed in terms of integrating geochemical and hydrological concerns. The coordination of the proposed research between the university of Waterloo and Homestake Mining Company's McLaughlin Mine is a model for public-private cooperation that offers significant cost benefits to the proposal. Finally, the proposed location for the work is extremely well chosen in terms of logistical factors.

I am pleased to offer my professional support for the proposal entitled, "Contamination - source control in the watershed: An evaluation of the in-situ removal of mercury from groundwater using permeable reactive barriers (PRBs)."

If you have questions or require additional information, please contact me.

Respectfully,
GEOCHIMICA, INC.

Mark J. Logsdon

Mark J. Logsdon, Principal Geochemist

HOMESTAKE MINING COMPANY

McLaughlin Mine

May 10, 2000

TO: CALFED Bay-Delta Program

RE: Research Proposal, "Contaminant-source control in the watershed: an evaluation of the *in situ* removal of mercury from groundwater using permeable reactive barriers (PRBs)"

To Whom It May Concern:

This letter is to advise the CALFED Bay-Delta Program that our management supports the above research proposal, submitted by Dr. David Blowes and his staff from the University of Waterloo, Ontario, Canada.

This proposal is in keeping with the goals of Homestake Mining Company's McLaughlin mine to actively participate in and support public/private collaborative research efforts that promote innovative approaches to issues related to watershed management and the ecological health of the region. As an active participant in watershed management in both the Cache Creek and Putah Creek watersheds, Homestake has demonstrated its interest in the past by supporting such activities, including ongoing aquatic ecology research at its Davis Creek Reservoir and local tributary streams.

Dr. Blowes' proposal is also in keeping with the mutual goal of Homestake Mining Company and the University of California Natural Reserve System (UCNRS) to encourage multi-disciplinary research at the McLaughlin mine site. The UCNRS and Homestake Mining Company are working together to encourage such activities, as the emphasis and use of the facility shifts from mining to ecological research in the next few years. Dr. Blowes' proposal is a welcome addition to the building level of high quality research at the McLaughlin mine site, as it undergoes its transition to become the Donald & Sylvia McLaughlin Natural Reserve.

Homestake Mining Company funded the initial laboratory-scale testing of the local applicability of this technology in 1999, at a cost of $16,500, and is pleased to contribute to the field-based study (as described in the above proposal) by providing full use of the facilities at the McLaughlin Reserve for this next phase of research.

If you have any questions, please feel free to contact me at 707-995-6070 ext. 274.

Sincerely,

Dean A. Enderlin
Senior Environmental Engineer

Homestake Mining Co., McLaughlin Mine
26775 Morgan Valley Road
Lower Lake, CA 95457

Telephone (707) 995-6070
FAX (707) 995-6078

TRC

May 11, 2000

Project No. 99-0003-99

University of Waterloo
Department of Earth Sciences
200 University West
Waterloo, Ontario, Canada
N2L-3G1

SUBJECT: Letter of Professional Support for CALFED Bay Delta Research Proposal – "Contaminant-source control in the watershed: an evaluation of the *in situ* removal of mercury from groundwater using permeable reactive barriers

To Whom It May Concern,

The purpose of this letter is to identify that TRC and, in particular, Dr. Ian Hutchison, Ph.D., will provide professional support for the above referenced proposal. TRC is a national environmental consulting firm with extensive experience in mining projects on both a national and international basis. This has included performance of numerous mine water quality related projects, with a primary focus on the impacts of uncontrolled discharge of acid rock drainage, evaluation of environmental impacts from metal laden mine waste, and focused analysis on the fate and transport of these chemicals and their discharge into the local watersheds.

TRC was the Engineer of Record for the recently completed Penn Mine reclamation project in the Sierra Nevada foothills in California. In that capacity, TRC was responsible to evaluate, monitor and mitigate acid-rock drainage (ARD) from mine tailings at an abandoned mine site. The site reclamation was expedited to eliminate "fish kills" that had occurred as a result of uncontrolled ARD releases into the local watershed, which ultimately discharges into the California delta system.

Dr. Ian Hutchison will provide technical guidance and peer review support services for this important project. Dr. Ian Hutchison was the principal reviewer and editor for the *Mine Waste Management Manual*, published by the California Mining Association. This manual is a valuable resource for mining industry professionals, regulators and consulting engineers involved in mine reclamation activities throughout the Western United States.

If needed, Dr. Ian Hutchison will mobilize team resources from TRC's Concord Office located in Northern California. Mr. Deems Padgett, R.G., is the Senior Manager in TRC's Concord office and will provide resource center and management support, as needed. Mr. Padgett was the Project Manager for the above described Penn Mine reclamation project.

5052 Commercial Circle • Concord, California 94520
Telephone 925-688-1200 • Fax 925-688-0388

In summary, we believe that completion of this proposal to evaluate the potential for mercury discharges into delta watersheds is an important and timely effort. We look forward to supporting this project in a meaningful capacity.

Sincerely,

for Ian P.G. Hutchison, Ph.D., P.E.
Senior Vice-President

Deems C. Padgett, R.G., C.E.G., H.G.
Project Director

Environmental Compliance Checklist

All applicants must fill out this Environmental Compliance Checklist. Applications must contain answers to the following questions to be responsive and to be considered for funding. *Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.*

1. **Do any of the actions included in the proposal require compliance with either the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), or both?**

   _____ YES ___X___ NO

2. **If you answered yes to # 1, identify the lead governmental agency for CEQA/NEPA compliance.**

   _____
   Lead Agency

3. **If you answered no to # 1, explain why CEQA/NEPA compliance is not required for the actions in the proposal.**
   This is a small-scale self-contained laboratory experiment. Impacts on the environment are not expected and no surface disturbance will occur. Groundwater collected from the Knoxville Mine site will be used in the column experiments conducted in the laboratory. Full treatment of the dissolved mercury is expected with the column reactive materials, however, any water exceeding discharge guidelines will be disposed of under Homestake Mining Company's environmental management system.
4. **If CEQA/NEPA compliance is required, describe how the project will comply with either or both of these laws. Describe where the project is in the compliance process and the expected date of completion.**

5. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   _____ YES ___X___ NO

   If yes, the applicant must attach written permission for access from the relevant property owner(s). Failure to include written permission for access may result in disqualification of the proposal during the review process. Research and monitoring field projects for which specific field locations have not been identified will be required to provide access needs and permission for access with 30 days of notification of approval.

6. Please indicate what permits or other approvals may be required for the activities contained in your proposal. Check all boxes that apply.

LOCAL		
Conditional use permit	___	
Variance	___	
Subdivision Map Act approval	___	
Grading permit	___	
General plan amendment	___	
Specific plan approval	___	
Rezone	___	
Williamson Act Contract cancellation	___	
Other _____ (please specify)		
None required	_X_	
STATE		
CESA Compliance	___	(CDFG)
Streambed alteration permit	___	(CDFG)
CWA § 401 certification	___	(RWQCB)
Coastal development permit	___	(Coastal Commission/BCDC)
Reclamation Board approval	___	
Notification	___	(DPC, BCDC)
Other _____ (please specify)		
None required	_X_	
FEDERAL		
ESA Consultation	___	(USFWS)
Rivers & Harbors Act permit	___	(ACOE)
CWA § 404 permit	___	(ACOE)
Other _____ (please specify)		
None required	_X_	

DPC = Delta Protection Commission
CWA = Clean Water Act
CESA = California Endangered Species Act
USFWS = U.S. Fish and Wildlife Service
ACOE = U.S. Army Corps of Engineers

ESA = Endangered Species Act
CDFG = California Department of Fish and Game
RWQCB = Regional Water Quality Control Board
BCDC= Bay Conservation and Development Comm.

Land Use Checklist

All applicants must fill out this Land Use Checklist for their proposal. Applications must contain answers to the following questions to be responsive and to be considered for funding. *Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.*

1. **Do the actions in the proposal involve physical changes to the land(i.e. grading, planting vegetation, or breeching levees) or restrictions in land use (i.e. conservation easement or placement of land in a wildlife refuge)?**

   _____ YES __X__ NO

2. **If NO to # 1, explain what type of actions are involved in the proposal (i.e., research only, planning only).**
   This is a small-scale self-contained laboratory experiment. Impacts on the environment are not expected and no surface disturbance will occur. Groundwater collected from the Knoxville Mine site will be used in the column experiments conducted in the laboratory on Homestake Mining Company property.
3. **If YES to # 1, what is the proposed land use change or restriction under the proposal?**

4. **If YES to # 1, is the land currently under a Williamson Act contract?**

   _____ YES _____ NO

5. **If YES to # 1, answer the following:**

   Current land use _____
   Current zoning _____
   Current general plan designation _____

6. **If YES to #1, is the land classified as Prime Farmland, Farmland of Statewide Importance or Unique Farmland on the Department of Conservation Important Farmland Maps?**

   _____ YES _____ NO _____ DON'T KNOW

7. **If YES to # 1, how many acres of land will be subject to physical change or land use restrictions under the proposal?**
   _____

8. **If YES to # 1, is the property currently being commercially farmed or grazed?**

   _____ YES _____ NO

9. **If YES to #8, what are** **the number of employees/acre**_____
   the total number of employees _____

10. Will the applicant acquire any interest in land under the proposal (fee title or a conservation easement)?

_____ YES ___X___ NO

11. What entity/organization will hold the interest?_____

12. If YES to # 10, answer the following:

Total number of acres to be acquired under proposal _____
Number of acres to be acquired in fee _____
Number of acres to be subject to conservation easement _____

13. For all proposals involving physical changes to the land or restriction in land use, describe what entity or organization will:

manage the property _____

provide operations and maintenance services _____

conduct monitoring _____

14. For land acquisitions (fee title or easements), will existing water rights also be acquired?

_____ YES _____ NO

15. Does the applicant propose any modifications to the water right or change in the delivery of the water?

_____ YES ___X___ NO

16. If YES to # 15, describe_____

APPLICATION FOR FEDERAL ASSISTANCE

OMB Approval No. 0348-0043

2. DATE SUBMITTED	Applicant Identifier
12 May 2000	
3. DATE RECEIVED BY STATE	State Application Identifier
4. DATE RECEIVED BY FEDERAL AGENCY	Federal Identifier

1. TYPE OF SUBMISSION:

Application	Preapplication
☐ Construction	☐ Construction
☒ Non-Construction	☐ Non-Construction

5. APPLICANT INFORMATION

Legal Name: University of Waterloo

Organizational Unit: Institute for Groundwater Research

Address *(give city, county, State, and zip code)*:
200 University Avenue
Waterloo, Ontario N2L 3G1
Canada

Name and telephone number of person to be contacted on matters involving this application *(give area code)*
Technical: David Blowes (519) 888-4567 ext4878
Admin: Judy Brown (519) 888-4567 ext2022

6. EMPLOYER IDENTIFICATION NUMBER *(EIN)*: 98-0061413

7. TYPE OF APPLICANT: *(enter appropriate letter in box)* I

A. State
B. County
C. Municipal
D. Township
E. Interstate
F. Intermunicipal
G. Special District
H. Independent School Dist.
I. State Controlled Institution of Higher Learning
J. Private University
K. Indian Tribe
L. Individual
M. Profit Organization
N. Other (Specify) _____

8. TYPE OF APPLICATION:

☒ New ☐ Continuation ☐ Revision

If Revision, enter appropriate letter(s) in box(es) ☐ ☐

A. Increase Award B. Decrease Award C. Increase Duration
D. Decrease Duration Other *(specify)*:

9. NAME OF FEDERAL AGENCY:
CALFED

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: ☐☐ – ☐☐☐

TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:
Contaminant-source control in the watershed: an evaluation of the in situ removal of mercury from groundwater using permeable reactive barrier (PRBs)

12. AREAS AFFECTED BY PROJECT *(Cities, Counties, States, etc.)*:

13. PROPOSED PROJECT

Start Date	Ending Date
1 Feb 2001	31 Jan 2002

14. CONGRESSIONAL DISTRICTS OF:

a. Applicant	b. Project

15. ESTIMATED FUNDING:

a. Federal	$ .00
b. Applicant	$ .00
c. State	$ .00
d. Local	$ .00
e. Other In-Kind Homestake Mining	$ 16,500.00
f. Program Income	$ .00
g. TOTAL	$ 208,235.00

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE _____

b. No. ☐ PROGRAM IS NOT COVERED BY E. O. 12372
☐ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?

☐ Yes If "Yes," attach an explanation. ☒ No

18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.

a. Type Name of Authorized Representative	b. Title	c. Telephone Number
BRENDA HEBNER	Manager Contracts/ Industrial Grants	(519) 888-4567 ext. 2021
d. Signature of Authorized Representative		e. Date Signed
		12 May 2000

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Standard Form 424 (Rev. 7-97)
Prescribed by OMB Circular A-102

STATE OF CALIFORNIA

NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95)

COMPANY NAME: UNIVERSITY OF WATERLOO, Waterloo, Ontario, Canada

The company named above (herinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), medical condition (cancer), age (over 40), marital status, denial of family care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME: BRENDA HEBNER
Manager Contracts/ Industrial Grants

DATE EXECUTED: 12 May 2000

EXECUTED IN THE COUNTY OF:

PROSPECTIVE CONTRACTOR'S SIGNATURE: Brenda Hebner

PROSPECTIVE CONTRACTOR'S TITLE:

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME: UNIVERSITY OF WATERLOO

U.S. Department of the Interior

Certifications Regarding Debarment, Suspension and Other Responsibility Matters, Drug-Free Workplace Requirements and Lobbying

Persons signing this form should refer to the regulations referenced below for complete instructions:

Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions - **The prospective primary participant further agrees by submitting this proposal that it will include the clause titled, "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions.** See below for language to be used; use this form for certification and sign; or use Department of the Interior Form 1954 (DI-1954). (See Appendix A of Subpart D of 43 CFR Part 12.)

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions - (See Appendix B of Subpart D of 43 CFR Part 12.)

Certification Regarding Drug-Free Workplace Requirements - Alternate I. (Grantees Other Than Individuals) and Alternate II. (Grantees Who are Individuals) - (See Appendix C of Subpart D of 43 CFR Part 12.)

Signature on this form provides for compliance with certification requirements under 43 CFR Parts 12 and 18. The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of the Interior determines to award the covered transaction, grant, cooperative agreement or loan.

PART A: Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions

CHECK ✓ IF THIS CERTIFICATION IS FOR A PRIMARY COVERED TRANSACTION AND IS APPLICABLE.

(1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:

(a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;

(b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and

(d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.

(2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

PART B: Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions

CHECK __ IF THIS CERTIFICATION IS FOR A LOWER TIER COVERED TRANSACTION AND IS APPLICABLE.

(1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.

(2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

DI-2010
March 1995
(This form consolidates DI-1953, DI-1954, DI-1955, DI-1956 and DI-1963)

PART C: Certification Regarding Drug-Free Workplace Requirements

CHECK __ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS NOT AN INDIVIDUAL.

Alternate I. (Grantees Other Than Individuals)

A. The grantee certifies that it will or continue to provide a drug-free workplace by:

(a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;

(b) Establishing an ongoing drug-free awareness program to inform employees about--
(1) The dangers of drug abuse in the workplace;
(2) The grantee's policy of maintaining a drug-free workplace;
(3) Any available drug counseling, rehabilitation, and employee assistance programs; and
(4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;

(c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);

(d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will --
(1) Abide by the terms of the statement; and
(2) Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than five calendar days after such conviction;

(e) Notifying the agency in writing, within ten calendar days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction. Employers of convicted employees must provide notice, including position title, to every grant officer on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification number(s) of each affected grant;

(f) Taking one of the following actions, within 30 calendar days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted --
(1) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or
(2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;

(g) Making a good faith effort to continue to maintain a drug-free workplace though implementation of paragraphs (a), (b), (c), (d), (e) and (f).

B. The grantee may insert in the space provided below the site(s) for the performance of workdone in connection with the specific grant:

Place of Performance (Street address, city, county, state, zip code)

_____

_____

_____

Check __ if there are workplaces on file that are not identified here.

PART D: Certification Regarding Drug-Free Workplace Requirements

CHECK __ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS AN INDIVIDUAL.

Alternate II. (Grantees Who Are Individuals)

(a) The grantee certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant;

(b) If convicted of a criminal drug offense resulting from a violation occurring during the conduct of any grant activity, he or she will report the conviction, in writing, within 10 calendar days of the conviction, to the grant officer or other designee, unless the Federal agency designates a central point for the receipt of such notices. When notice is made to such a central point, it shall include the identification number(s) of each affected grant.

PART E: Certification Regarding Lobbying
Certification for Contracts, Grants, Loans, and Cooperative Agreements

CHECK √ IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND THE AMOUNT EXCEEDS $100,000: A FEDERAL GRANT OR COOPERATIVE AGREEMENT, SUBCONTRACT, OR SUBGRANT UNDER THE GRANT OR COOPERATIVE AGREEMENT.

CHECK __ IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL LOAN EXCEEDING THE AMOUNT OF $150,000, OR A SUBGRANT OR SUBCONTRACT EXCEEDING $100,000, UNDER THE LOAN.

The undersigned certifies, to the best of his or her knowledge and belief, that:

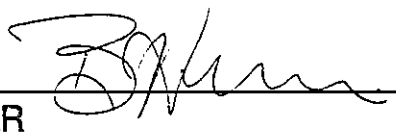
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

As the authorized certifying official, I hereby certify that the above specified certifications are true.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL 

TYPED NAME AND TITLE BRENDA HEBNER
Manager Contracts/
Industrial Grants

DATE 12 May 2000

DI-2010

March 1995

(This form consolidates DI-1953, DI-1954, DI-1955, DI-1956 and DI-1963)